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ORIGINAL ARTICLE

Factors Affecting Length of Stay in the Pediatric Emergency Department

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Background: A large volume of visits can cause an emergency department (ED) to become overcrowded, resulting in a longer length of stay (LOS). The objective of this study was to analyze factors affecting the LOS in the pediatric ED.
Methods: Records of all visits to the pediatric ED of the study hospital, from July 1, 2006 to June 31, 2007, were retrospectively retrieved. Data were collected from the hospital's computerized records system. Eta-squared correlation ratio and Cramer's *V* test evaluated the associations between variables. Two-thirds of the database was randomized for the classification and regression tree (CART) model-building dataset, and one-third was used for the validation dataset.
Results: A total of 29,035 patients visited the pediatric ED during the evaluation period. Of the total visits, 61.1% were due to complaints of fever. The mean LOS was 2.6 $\pm$ 4.67 hours, and 74.3% of visits had an LOS of shorter than 2 hours. The CART analysis selected five factors (waiting time for hospitalization, laboratory tests, door-to-physician time, gastrointestinal symptoms, and patient outcome) to produce a total of nine subgroups of patients. The mean LOS of the model-building dataset closely correlated with that of the validation dataset ($r^2 = 0.999$).
Conclusion: Patients who were waiting for hospitalization for less than 8 hours or were not admitted, those without any laboratory tests, those having door-to-physician time less than 60 minutes, and those without any gastrointestinal symptoms had the shortest LOS. Patients who waited for hospitalization for more than 16 hours had the longest LOS.

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1. Introduction

An increasing number of patients visit hospital emergency departments (EDs) for treatment.[1,2] In the USA, children younger than 15 years have an ED utilization rate of approximately 35.1 per 100 persons, accounting for 23% of total ED visits.[1] According to data from the Bureau of National Health Insurance in Taiwan, the annual number of ED visits increased from 4.99 million in 1996 to 7.23 million in 2010. A large volume of visits may lead to overcrowding of the ED, as reflected by longer patient waiting times. This may place patients at a greater risk of poor outcomes.[3–5] Length of stay (LOS) is one of the important quality factors in the ED, where prolonged waiting time can increase the likelihood of patient dissatisfaction.[6–8] Several factors influence the LOS of adult patients, including patient characteristics; the requirement for further evaluations, such as radiology studies and laboratory tests; the need for sedation or special procedures; and the waiting time for hospitalization.[9–15] In one US study, investigators reported that factors independently associated with an LOS of more than 10 hours in a pediatric ED were longer waiting time, night shift arrival, high triage acuity, radiology studies, and subspecialty consultations.[16] Risk factors may differ in various areas, and, as yet, no study in Taiwan has published data concerning factors associated with LOS in the pediatric ED. The present retrospective study thus aims at identifying the varying factors associated with the LOS in the pediatric ED. Results may prove useful for hospital strategy development and for improving quality in the pediatric ED.

A classification and regression tree (CART) analysis is a core component of the decision tree tool for data mining and predictive modeling.[17] CART is a nonparametric discriminant method based on statistical theory. It is structured in two parts: a classification tree and a regression tree. The classification tree uses a nominal variable as the dependent variable, and the regression tree uses a continuous variable as the dependent variable.[18] Results of the CART analysis are presented as a decision tree, which separates patients into subgroups following the flowchart form. The flowchart structure and rules can easily be explained and are easy to understand. Recent studies have shown CART to provide as meaningful an analysis as other traditional statistical techniques, such as linear regression and logistic regression analyses.[18–20] Some earlier studies had used CART to analyze factors associated with the LOS in a hospital,[21,22] but this is the first study that used CART to construct a model to predict LOS and analyze the factors affecting LOS in the pediatric ED.

2. Methods

This study was approved by the Mackay Memorial Hospital Institutional Review Board. Computerized records of all visits to the pediatric ED of the study hospital, from July 1, 2006 to June 31, 2007, were retrieved. All patients younger than 18 years who registered at the pediatric ED were included in the analyses.

The study hospital is a secondary teaching hospital in northern Taiwan, which receives approximately 30,000 emergency visits per year. Triage nurses were required to enter patient registration data, including triage level, age, body weight, sex, arrival time, chief complaint, vital signs, and medication allergy history, into the hospital computer network.

After the waiting time, children were evaluated and treated by the attending or resident pediatric physicians. Pediatric physicians recorded patients' clinical conditions, physical examination results, medications, and necessary laboratory or radiology tests.

Data collected included information on triage level, age, sex, registration and discharge time, time of physician's first order, time of transfer to observation unit, chief complaint, image study, laboratory tests, consultation, and final patient outcome. All computerized medical records of every revisit were reviewed by one of the authors.

The time of registration at the ED was considered as the time of the visit. LOS was calculated as the time period between registration of patients and the time of their physically leaving the ED, whether admitted or discharged. Door-to-physician time was calculated as the time period between the arrival at triage and the first evaluation by a physician. If no beds were available when patients needed hospitalization for more treatment, they had to be sent to the observation unit at the ED, where they should wait for admission. The waiting time for hospitalization was calculated as the time between when they were sent to the observation unit and the time of their admission.

Age was divided into five groups: (1) younger than 3 months, (2) 3 months to 1 year, (3) 1–6 years, (4) 7–12 years, and (5) 13–18 years. The time of patients' registration was decided based on the three shifts of a day: day shift (8:00 AM to 4:00 PM), evening shift (4:00 PM to 12:00 midnight), and night shift (12:00 midnight to 8:00 AM). The days of a week were divided into weekdays (Monday to Friday; outpatient department available in the mornings and afternoons), Saturdays (outpatient department available in the mornings only), and holidays (outpatient department closed).

According to the body system, chief complaints were categorized into six groups: (1) fever as the predominant symptom, (2) gastrointestinal symptoms, (3) respiratory symptoms, (4) dermatological symptoms, (5) neurological symptoms, and (6) other symptoms or complaints. One patient may have had one symptom or more than one symptom occurring simultaneously.

Door-to-physician time was categorized into five groups: (1) less than 10 minutes, (2) 10–30 minutes, (3) 30–60 minutes, (4) 60–120 minutes, and (5) more than 120 minutes.

Waiting time for hospitalization was categorized into five groups: (1) nonadmission or no bed available, (2) less than 8 hours, (3) 8–16 hours, (4) 16–24 hours, and (5) more than 24 hours.

Patient outcome was categorized into six groups: (1) discharge, (2) ward admission, (3) intensive care unit (ICU) admission, (4) transfer to another hospital, (5) discharge against medical advice, and (6) death.

This study also collected information on whether these patients had undergone consultation by other subspecialty physicians, and had image and laboratory studies.

Data were collected from the computerized records system of the hospital and entered into Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Statistical analysis was performed using SPSS 17.0 Windows, version 7, software. Data for categorical variables were analyzed using the chi-square or Fisher's exact test. Data for continuous variables were analyzed using one analysis of variance, as appropriate. A p value of <0.05 was considered statistically significant. Distributions of variables were reported as percentages and mean $\pm$ standard deviation. Pearson's correlation coefficient was used for comparisons between two continuous variables. The eta-squared correlation ratio was used to evaluate the association between nominal and continuous variables. Cramer's V was used to evaluate the association between nominal variables. Eta-squared and Cramer's V values range between 0 and 1; a value close to 0 indicates a weak association between variables, whereas that close to 1 indicates a strong association. An eta-squared value of <0.01 or a Cramer's V value of <0.1 indicates that there is almost no association between the two variables.[23–26]

A CART, created using all the variables, predicted a patient's LOS. Using SPSS software, two-thirds of the database was randomized completely and used for the model-building dataset, and one-third was used for the validation dataset. The CART procedure ceased to work when no additional significant variable was detected or when the sample size was below 100. All statistical calculations were performed using SPSS 17th edition for Windows 7 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Demographic information of enrolled patients

A total of 29,035 patients visited the pediatric ED of the Mackay Memorial Hospital (Hsinchu branch) between July 1, 2006 and June 31, 2007. The patients included 16,230 (55.9%) boys and 12,805 (44.1%) girls, ranging in age from newborn to 18 years (mean age, 43.98 $\pm$ 38.13 months). Table 1 presents the demographic information, registration times, dates of registration, chief complaints, door-to-physician time, consultations, image study, laboratory tests, waiting time for hospitalization, and outcomes of patients.

A total of 15,181 patients (52.3%) were classified into Triage Level 3, representing the most common population, while Triage Level 4 had the smallest population. In total, 19,500 patients (67.2%) ranged in age from 1 to 6 years, representing the most common population, followed by 4581 patients (15.8%) with ages ranging from 3 months to 1 year. The least common population was patients older than 13 years (2.1%). In total, 13,151 patients (45.3%) registered during evening shifts, 7846 (27%) during day shifts, and 8038 (27.7%) during night shifts.

A total of 17,025 patients visited the pediatric ED on weekdays (67.6 $\pm$ 12.7 patients daily), 4417 patients on Saturdays (83.3 $\pm$ 12.6 patients daily), and 7593 patients on holidays (126.6 $\pm$ 20.6 patients daily). In total, 17,741 patients (61.1%) visited the pediatric ED with fever as the chief complaint, followed by 11,474 (39.5%) with

Table 1 Demographic information of 29,035 pediatric emergency patients.

	n	%
Sex		
Male	16,230	44.1
Female	12,805	55.9
Triage level		
1	8396	28.9
2	5350	18.4
3	15,181	52.3
4	108	0.4
Age		
< 3 mo	1011	3.5
3 mo to 1 y	4581	15.8
1–6 y	19,500	67.2
7–12 y	3347	11.5
13–18 y	596	2.1
Registration time		
Day shift	7846	27
Evening shift	13,151	45.3
Night shift	8038	27.7
Date		
Weekday	17,025	58.6
Saturday	4417	15.2
Holiday	7593	26.2
Chief problem of an ill body system		
Fever	17,741	61.1
Gastrointestinal symptoms	11,474	39.5
Respiratory symptoms	10,783	37.1
Dermatologic symptoms	2066	7.1
Neurological symptoms	1260	4.3
Door-to-physician time		
< 10 min	5203	17.9
10–30 min	14,321	49.3
30–60 min	6098	21.0
60–120 min	3022	10.4
> 120 min	391	1.3
Consultations		
Yes	26	0.1
No	29,009	99.9
Image study		
Yes	6021	20.7
No	23,014	79.3
Laboratory tests		
Yes	7983	27.5
No	21,052	72.5
Waiting time for hospitalization		
Nonadmission or no waiting time	28,074	96.7
< 8 h	231	0.8
8–16 h	324	1.1
16–24 h	338	1.2
> 24 h	68	0.2
Outcome of the patients	3	
Discharge	25,818	88.9
Ward admission	2613	9
ICU admission	99	0.3
Transfer to another hospital	166	0.6
Discharge against medical advice	336	1.2
Death	3	<0.1

ICU = intensive care unit.

gastrointestinal symptoms and 10,783 (37.1%) with respiratory symptoms. Door-to-physician time for 14,321 patients (49.3%) was "10–30 minutes", while 1.3% waited more than 2 hours between registration and seeing a doctor. Twenty-six patients (0.1%) had subspecialty consultations, 6021 patients (20.7%) underwent image study, and 7983 patients (27.5%) went through laboratory tests.

In total, 961 patients (3.3%) stayed in the emergency observation unit to await hospitalization. Sixty-eight patients waited more than 24 hours. The final outcomes of patients were as follows: discharge in case of 25,818 patients (88.9%), ward admission in 2613 patients (9%), admission to ICUs in 99 patients (0.3%), transfer to another hospital in 166 patients (0.6%), and discharge against medical advice in 336 patients (1.2%). Three patients died after cardiopulmonary resuscitation.

3.2. Length of stay

The mean total LOS was 2.6 $\pm$ 4.67 hours. An LOS of 0.5–2 hours was most common (44.4%), and less than 2 hours accounted for 74.3% of the LOS. There were 249 (0.9%) patients with an LOS of more than 24 hours. Patients waiting for admission for more than 24 hours had the longest LOS (33.27 $\pm$ 7.26 hours). The mean LOS in patients younger than 3 months was 0.99 $\pm$ 1.35 hours, which was relatively shorter than the mean LOS in other age groups (Table 2). For triage status, Triage Level 4 group had a shorter LOS (1.02 $\pm$ 3.18) than other triage statuses. Patients with subspecialty consultations, who underwent image study or laboratory tests, had a longer LOS than those without. Patients having longer door-to-physician time or waiting time for hospitalization would have a longer LOS.

For the chief problem of an ill body system, febrile or afebrile patients had almost identical LOSs (2.64 $\pm$ 4.83 vs. 2.54 $\pm$ 4.40 hours). Patients with gastrointestinal symptoms had a longer LOS than those without (3.44 $\pm$ 5.39 vs. 2.06 $\pm$ 4.04 hours). However, patients with respiratory symptoms had a shorter LOS than those without (2.05 $\pm$ 4.15 vs. 2.93 $\pm$ 4.92 hours). For patient outcome, patients who died or were admitted to the ICU had a shorter LOS than other subgroups. Patients admitted to wards had the longest LOS. Differences in LOSs between variables were all significant ($p < 0.05$), except for those between febrile and afebrile patients ($p > 0.05$).

3.3. Analyses of the chief problem of an ill body system and patient outcomes of different age groups

In patients younger than 12 years, fever represented the most common chief complaint, and the highest frequency was in 3-month- to 1-year-old patients (69.1%; Table 3). Frequency of gastrointestinal symptoms exceeded that of fever in the 13–18-year-old group. Gastrointestinal symptoms were most common in the 13–18-year-old group and least common in the younger-than-3-months group (46.5% vs. 21.7%, Cramer's $V = 0.12$, $p < 0.01$). Frequency of respiratory symptoms ranged between 26.8% and 37.8% (Cramer's $V = 0.043$) and that of dermatological symptoms ranged between 6.6% and 8.1% (Cramer's $V = 0.02$) in all age groups. Neurological symptoms were most common in the 13–18-year-old group (17%, Cramer's $V = 0.178$, $p < 0.01$).

The hospital discharged 507 (50.2%) patients in the younger-than-3-months group after visiting the pediatric ED. This was the lowest frequency of all age groups (Cramer's $V = 0.252$, $p < 0.01$). These patients also had the highest frequency of ward admissions (40.3%, Cramer's $V = 0.222$, $p < 0.01$) and ICU admissions (5.4%, Cramer's $V = 0.167$, $p < 0.01$).

3.4. CART analysis

The CART analysis of the model-building dataset of 19,428 patients (66.9%) included 13 categorical variables (sex, triage level, registration time, registration date, fever, gastrointestinal symptoms, respiratory symptoms, dermatological symptoms, neurological symptoms, consultations, image study, laboratory tests, and patient outcome) and three ordinal variables (age, door-to-physician time, and waiting time for hospitalization). Figure 1 shows the resulting decision tree. The CART analysis automatically selected five predictive variables (waiting time for hospitalization, laboratory tests, door-to-physician time, gastrointestinal symptoms, and patient outcome) to produce nine patient subgroups. Outcome of patients was selected as the variable for the initial separation of data between waiting time for hospitalization shorter than 8 hours and that of longer than 8 hours. The mean LOS of patients with waiting time for hospitalization shorter than 8 hours was 2.15 $\pm$ 3.64 hours, and that longer than 8 hours was 19.77 $\pm$ 6.90 hours. The shortest mean LOS occurred in the subgroup of patients with waiting time for hospitalization shorter than 8 hours, without laboratory tests, with door-to-physician time shorter than 60 minutes, and without gastrointestinal symptoms (0.72 $\pm$ 1.36 hours). The longest mean LOS occurred in the subgroup of patients with waiting time for hospitalization longer than 16 hours (23.70 $\pm$ 6.26 hours).

3.5. CART analysis validation

A validation dataset of 9607 patients validated the results of the CART analysis, with each patient allocated to one of Subgroups 1 to 9 using the CART flow chart. The mean LOSs were 0.72, 1.28, 1.68, 2.90, 3.98, 4.39, 8.19, 14.82, and 23.68 hours for Subgroups 1 to 9, respectively. The mean LOS in each subgroup of patients in the model-building dataset closely correlated with that in the validation dataset (Figure 2).

4. Discussion

In 2000, in the USA, children younger than 15 years accounted for 23% of total ED visits.[1] In Merrill et al's[27] study, children aged less than 4 years had almost twice the rate of ED visits compared to any other age group. In the present study, approximately two-thirds of patients (67.2%) visiting the ED were aged from 1 to 6 years. In Taiwan, many parents send their children to cram schools

Table 2 Mean LOS for each variable.

	LOS	Eta square	*F* value	*p*
Sex				
Male	2.55 ± 4.65	<0.001	4	0.045
Female	2.66 ± 4.70			
Triage level				
1	2.59 ± 4.72	0.002	19.186	<0.001
2	2.98 ± 5.09			
3	2.49 ± 4.48			
4	1.02 ± 3.18			
Age				
< 3 mo	0.99 ± 1.35	0.005	37.459	<0.001
3 mo to 1 y	2.73 ± 4.74			
1—6 y	2.71 ± 4.80			
7—12 y	2.29 ± 4.43			
13—18 y	2.50 ± 4.02			
Registration time				
Day shift	3.09 ± 5.25	0.005	68.773	<0.001
Evening shift	2.52 ± 4.73			
Night shift	2.25 ± 3.83			
Days				
Weekdays	2.83 ± 5.05	0.004	58.014	<0.001
Saturdays	2.5 ± 4.64			
Holiday	2.15 ± 3.63			
Chief problem of an ill body system				
Fever				
With	2.64 ± 4.83	<0.001	3.604	0.058
Without	2.54 ± 4.40			
Gastrointestinal symptoms				
With	3.44 ± 5.39	0.021	621.051	<0.001
Without	2.06 ± 4.04			
Respiratory symptoms				
With	2.05 ± 4.15	0.008	245.495	<0.001
Without	2.93 ± 4.92			
Dermatologic symptoms				
With	2.24 ± 4.49	<0.001	13.487	<0.001
Without	2.63 ± 4.68			
Neurological symptoms				
With	3.22 ± 5.23	0.001	22.903	<0.001
Without	2.57 ± 4.64			
Door-to-physician time				
< 10 min	2.17 ± 4.64	0.004	25.83	<0.001
10—30 min	2.58 ± 4.85			
30—60 min	2.76 ± 4.56			
60—120 min	2.94 ± 4.00			
> 120 minutes	4.01±3.87			
Consultations				
Yes	5.20 ± 5.04	<0.001	8.028	0.005
No	2.60 ± 4.67			
Image study				
Yes	3.77 ± 5.72	0.016	486.202	<0.001
No	2.30 ± 4.29			
Laboratory tests				
Yes	6.43 ± 6.85	0.256	9989.38	<0.001
No	1.15 ± 2.13			

(*continued on next page*)

Table 2 (*continued*)

	LOS	Eta square	F value	p
Waiting time for hospitalization				
Nonadmission or no waiting time	2.11 ± 3.64	0.389	4625.497	<0.001
< 8 h	7.63 ± 3.47			
8–16 h	14.47 ± 2.98			
16–24 h	21.77 ± 3.34			
> 24 h	33.27 ± 7.26			
Outcome of the patients				
Discharge	2.03 ± 3.67	0.133	891.952	<0.001
Ward admission	7.92 ± 8.54			
ICU admission	1.08 ± 1.93			
Transfer to another hospital	4.01 ± 5.30			
Discharge against medical advice	4.72 ± 3.86			
Death	0.99 ± 0.25			

Statistical analysis by ANOVA.
ANOVA = analysis of variance; ICU = intensive care unit; LOS = length of stay.

at this age. The crowded environment may result in these children contracting infections more easily and visiting the pediatric ED more frequently.

In the USA, the leading reasons for visits to the pediatric ED among children (aged under 15 years) were fever, cough, and vomiting.[28] In the present study, fever accounted for 17,741 (61.1%) of the pediatric ED patient visits. However, ratios differed in each age group. Patients with ages ranging from 3 to 12 months had the highest proportion of fever cases (69.1%), while those ranging in age from newborn to 3 months had the lowest proportion of fever cases. In the newborn-to-3-month group, it is probable that their parents were still unfamiliar with infant care, seeking help from the ED for diverse symptoms. With increasing age, fever gradually became the most common cause of visits to the ED. After the age of 13 years, the fever ratio decreased and gastrointestinal symptoms (46.5%) became the most common cause of visits to the pediatric ED. Ratios of respiratory symptom to dermatological symptom were almost identical in each age group. Neurological symptoms increased to 17% in patients aged from 13 to 18 years, presumably because patients of this age should be able to describe their symptoms more precisely.

Previous studies have reported associations of increased LOS with variables such as triage level, radiology studies, laboratory tests, special procedures, sedation, consultations, and waiting time for inpatient room availability.[9–15] One study identified that the average LOS of parental expectations was 2 hours and 36 minutes.[29] In the present study, the overall mean LOS of 2.6 hours is, therefore, close in value to the average LOS of parental expectations reported previously.[29] Patients visiting pediatric ED and

Table 3 Chief problem of an ill body system and patient outcomes in each age group.

Number of patients	< 3 mo	3 mo to 1 y	1–6 y	7–12 y	13–18 y	Cramer's V	p
	1011	4581	19,500	3347	596		
Chief problem of an ill body system							
Fever	357 (35.3%)	3168 (69.1%)	12,311 (63.1%)	1668 (49.8%)	237 (39.7%)	0.159	<0.001
Gastrointestinal symptoms	220 (21.7%)	1350 (29.5%)	8131 (41.7%)	1496 (44.7%)	277 (46.5%)	0.12	<0.001
Respiratory symptoms	271 (26.8%)	1693 (36.9%)	7373 (37.8%)	1249 (37.3%)	197 (33.1%)	0.043	<0.001
Dermatologic symptoms	67 (6.6%)	357 (7.8%)	1326 (6.8%)	272 (8.1%)	44 (7.4%)	0.02	0.02
Neurological symptoms	11 (1.1%)	37 (0.8%)	701 (3.6%)	410 (12.2%)	101 (17.0%)	0.178	<0.001
Outcome of patients							
Discharge	507 (50.2%)	3862 (84.3%)	17,724 (90.9%)	3162 (94.5%)	563 (94.5%)	0.252	<0.001
Ward admission	407 (40.2%)	571 (12.5%)	1462 (7.5%)	149 (4.6%)	24 (4.0%)	0.222	<0.001
ICU admission	55 (5.4%)	17 (0.4%)	23 (0.1%)	2 (0.1%)	2 (0.3%)	0.167	<0.001
Transfer to another hospital	34 (3.4%)	33 (0.7%)	79 (0.4%)	18 (0.5%)	2 (0.3%)	0.072	<0.001
Discharge against medical advice	7 (0.7%)	97 (2.1%)	212 (1.1%)	16 (0.5%)	4 (0.7%)	0.043	<0.001
Death	1 (0.1%)	1 (<0.1%)	0 (<0.1 %)	0 (<0.1%)	1 (0.2%)	0.029	<0.001

ICU = intensive care unit.

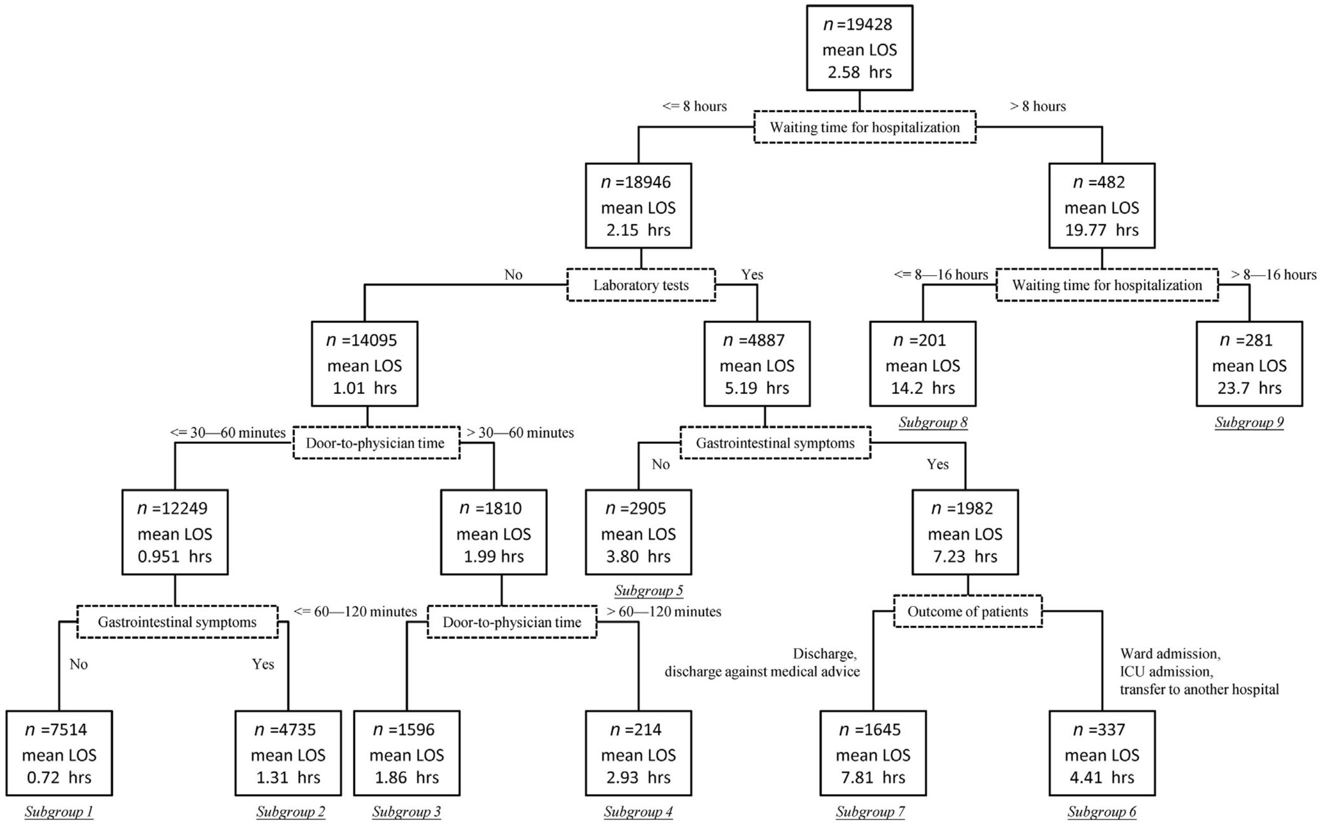

Figure 1 Classification and regression tree analysis. Boxes with dotted lines indicate factors used for the splitting. Boxes with solid lines show the number of patients and mean LOS. Terminal subgroups of patients discriminated by the analysis are numbered from 1 to 9. LOS = length of stay.

leaving within 2 hours comprised 74.3%. In the CART analysis, the first factor was waiting time for hospitalization, which was assessed according to two categories of less or more than 8 hours or not. The mean LOS was 19.77 hours for patients with waiting time more than 8 hours. In the left main branch of the decision tree, patients undergoing laboratory tests had a longer mean LOS than those who did not undergo the tests. This is because when patients underwent laboratory tests they waited at least 40—60 minutes for the results. Image study is not a split factor in the CART analysis; the likely cause is that waiting time for image results was about 15—20 minutes. It is relatively shorter than the time for laboratory tests. The next split factor is door-to-physician time (less than 60 minutes). Finally, patients with gastrointestinal symptoms had a shorter LOS than those without. The same condition was noted in Subgroup 5. Patients experiencing gastrointestinal symptoms such as diarrhea and vomiting tended to have a longer LOS. Because of the possibility of dehydration, parents of patients with these symptoms might have requested IV fluids and observation in the ED. Subgroup 7 comprised the patients who had gastrointestinal symptoms and who underwent laboratory tests; they seemed to need hydration and transfer to the observation unit, but finally left the hospital when their illness improved. If this group had more severe illnesses, hospitalization was suggested. Such patients were hospitalized as soon as possible, even transferred to another hospital for ward admission. For the above possibility, the LOS of Subgroup 6 was shorter than that of Subgroup 7.

The right main branch of the CART analysis concerned patients with waiting time for hospitalization more than 8 hours. In this branch, only one split factor—waiting time for hospitalization more than 16 hours or not—was selected. It means that if these patients stayed in the observation unit for more than 8 hours, laboratory tests, door-to-physician time, gastrointestinal symptoms, and patients' outcome would not affect the LOS.

Comparing with traditional statistical techniques, such as linear regression and logistic regression analyses, CART has some advantages and disadvantages. One limitation of the CART analysis in this study is that not all independent variables may be adopted in the decision tree, since we applied the rule to stop the CART procedure when the variables size was below 100. This rule was used to avoid the generation of an over-fit model that might lack universality. Advantages of the CART analysis include the following: (1) the ability to use different types of independent variables; (2) the ability to detect interactions and not to be affected easily by multicollinearity between variables compared to other regression modeling techniques; (3) invariance to transformations of dependent variables; and (4) the ability to handle missing values in both independent and dependent variables.[30,31] CART analyses are increasingly being accepted in medical research in addition to the biomedical field.[32—35] In O'Brien

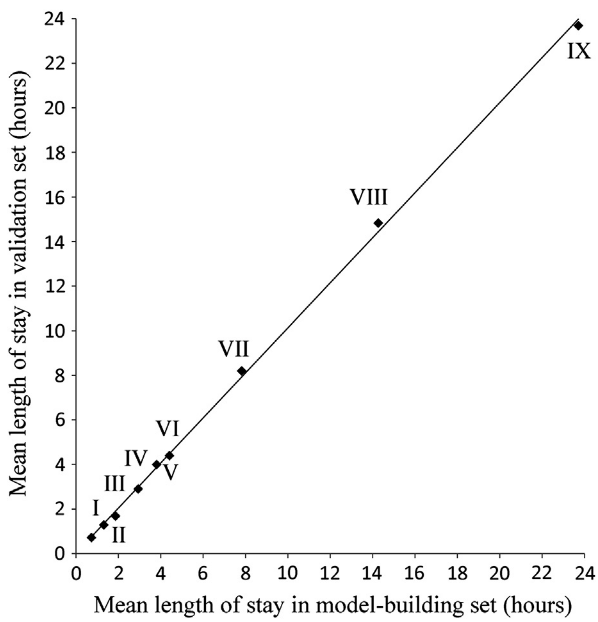

Figure 2 Validation of the CART analysis: subgroup-stratified comparison of the mean LOS between model-building and validation sets. Each patient in the validation set was allocated to one of subgroups 1–9 using the flow chart of the CART tree, and the mean LOS was calculated. The mean LOS in each subgroup was plotted. The mean LOS in each subgroup of patients closely correlated between the model-building dataset and the validation dataset ($r^2 = 0.999$); I to IX represent subgroups 1 to 9, respectively. CART = classification and regression tree; LOS = length of stay.

et al's[36] study, the accuracy rate of the CART model was even superior to that of the logistic regression model. However, CART analysis also has the following disadvantages: CART splits only by one variable and it may have unstable decision trees if the sample size is too small.[37]

The following factors affecting the LOS were unavailable in this study: the reason why patients were transferred to another hospital from the ED and how many pediatric doctors offered service simultaneously in the ED. In this study, the most important strategy was how to shorten waiting time for hospitalization in the observation unit. Finally, the results of this study represented a local pediatric ED situation; the situation may be different in other hospitals. We suggest that chiefs of hospitals should survey their pediatric ED in order to improve its quality.

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